Fermi National Accelerator Laboratory

FERMILAB-Conf-92/338-E

Dijet Invariant Mass Spectrum at CDF

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November 1992

Published Proceedings *Division of Particles and Fields Meeting*,
Fermi National Accelerator Laboratory, Batavia, Illinois, November 10-14, 1992

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy

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CDF/PUB/JET/PUBLIC/1892
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ABSTRACT

A summary of QCD results obtained using the dijet invariant mass spectrum $d\sigma/dM_{jj}$ is presented. The spectrum is compared with QCD Leading Order and with the recently published Next to Leading Order calculations[1]. A limit on the scale of an eventual quark compositness can be set at $\Lambda = 1300 GeV$. Limits on the production of new particles, decaying hadronically, are presented, too. Axigluons are ruled out in the mass range [240, 640] GeV, for a theory with N=10 strong interacting fermions, and in the two windows [260, 280] GeV and [450, 550] GeV, for N=20.

1. Data sample

Using 1988-89 CDF data, corresponding to an integrated luminosity $\int \mathcal{L}dt \simeq 4.2pb^{-1}$, we measured the differential cross section of the process $p + \bar{p} \to jet + jet + X$ as a function of the dijet invariant mass. For jet identification we use a cone algorithm[2], with cone radii of $R = \sqrt{\eta^2 + \phi^2} = 0.7$ and 1.0, that provides the momentum and the energy of each jet assuming a massless particle for each calorimeter tower belonging to the jet. No attempts have been made to recostruct the energy of the original parton, subtracting the energy that the underlying event presumably deposits inside the jet cone or adding the energy lost by radiation outside of the clustering cone. The events used in this analysis are selected with the request that the two leading jets be in the CDF central calorimeter ($|\eta| \leq 0.7$). No cuts have been applied on additional jets.

2. Comparison with QCD

A parametric function $f(M_{jj}) = aM_{jj}^{-b}e^{cM_{jj}}$ has been folded with the calorimeter response and fitted on data. The quantity (Data-Fit)/Fit is shown in fig.1 for the two clustering cones. On the same plot the LO and NLO predictions, normalized to data, for the Parton Distribution Function that better agrees with the measured spectrum (MT S1) and for a specific μ scale[1] are shown. The shape predicted with NLO calculations agrees with the data better than the LO prediction. This is more evident for the smaller cone, for which radiation losses are expected to be more relevant. We have performed a test of the shape of the predicted spectrum. The results[3] are reported in tab.1.

3. Compositness limits

The existence of an internal structure of the quarks can be accounted for by the addition to the standard QCD lagrangian of a four-fermion contact interaction

[1] In LO calculations $\mu = AP_t$, while in NLO $\mu = \frac{AM_{jj}}{2\cosh B\eta*}$, where $\eta*$ is the dijet pseudorapidity in their center of mass frame. We use $A = 0.5$ and $B = 0.7$.

Published Proceedings Division of Particles and Fields (DPF'92) Meeting, Fermi National Accelerator Laboratory, Batavia, IL, November 10-14, 1992.

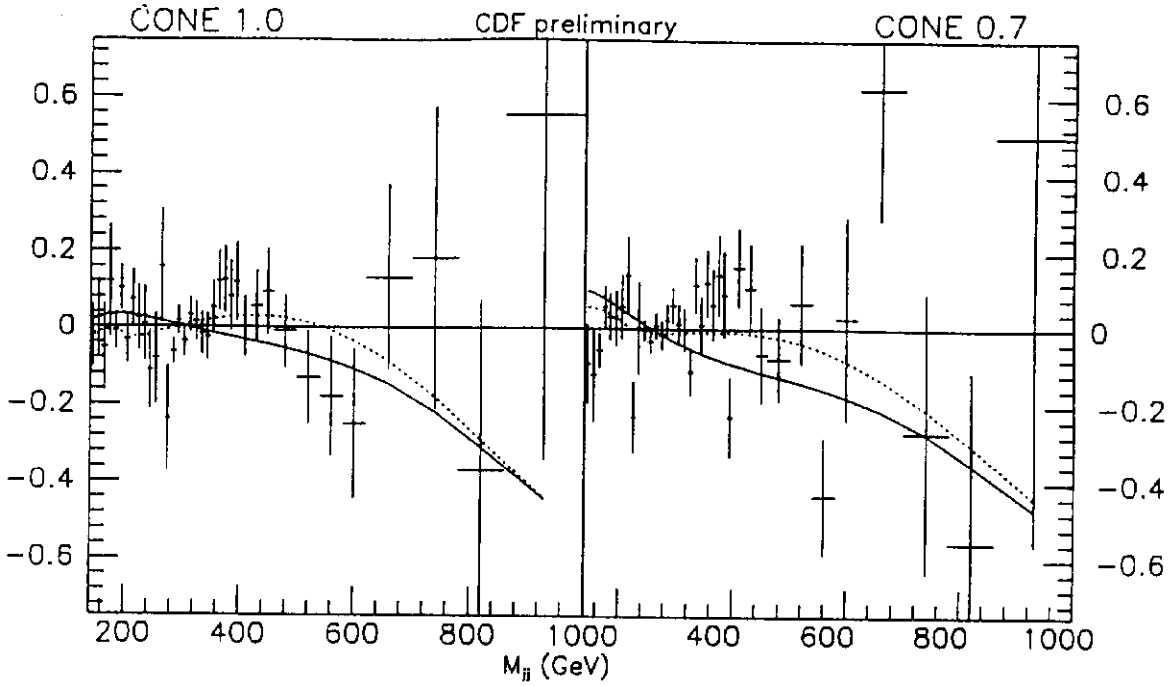

Figure 1: Dijet invariant mass spectrum in the region $|\eta_j| \leq 0.7$, for a clustering cone of 0.7 (a) and 1.0 (b). The lines are QCD LO (solid) and NLO (dashed) calculations with MTS1 PDFs.

Table 1: Shape comparison of the observed spectrum with LO and NLO predictions. The numbers indicate the Confidence Level (%) of the specific theory. (CDF preliminary)

	LO				NLO			
A	1.	0.5	1.	0.5	1.	0.5	1.	0.5
PDF	cone 1.0		cone 0.7		cone 1.0		cone 0.7	
HMRSB	47	46	1	1	58	57	3.6	4.6
MT S1	58	58	2	2	69	66	6.9	6.5
MT B2	64	64	4	5	not available			

term[4]. The presence of this interaction would lead to an excess of events in the high mass region of the M_{jj} spectrum. We have tested this theory by adding coherently to the QCD LO calculations a contact term. The theory so obtained has been normalized to data in the low region of the spectrum ($160 < M_{jj} < 300 GeV$) and then, looking at the high mass region ($M_{jj} > 580 GeV$), we have set on the compositness scale Λ the limits reported in tab.2.

4. Limits on resonances

To set limits on new particle cross section we have parametrized a generic resonance as a Breit-Wigner, having width proportional to the peak mass, incoherently superimposed on QCD LO calculations. We have then normalized the theory on data far from the resonance and looked at an eventual excess in the bump region. In order to be indipendent from the unknown value of the top mass, we set limits on the cross section times the BR of decaying to light quarks only. The cross section

Table 2: Compositness limit (GeV) at 95% CL. (CDF preliminary)

μ/P_t	0.5	1	2
HMRSB	1300	1330	1360
MT E1	1390	1440	1490
MT B1	1360	1410	1460
MT B2	1490	1540	1580

Table 3: Lower limits (95% CL) on [Observed cross section]×BR (pb) for a general resonance having width proportional to mass. (CDF preliminary)

		200	300	400	500	600	700	800	900
$\Gamma = 1\%M$	HMRSB	4908	341	80	13	14	12	6	5
$\Gamma = 1\%M$		2603	79	44	9	7	9	4	2
$\Gamma = 5\%M$	MT B2	3073	241	60	7	10	9	5	5
$\Gamma = 10\%M$		3628	214	48	13	13	11	5	7

is integrated in our acceptancy region: $|\eta| < 0.7$ for the two leading jets. In spite of the simplifying assumptions of this approach (no spin effect, no interference with QCD, no convolution with PDF) the limits we set are useful as a crude check of theorists' favourite resonances. Results are reported in tab.3. The same method has been applied to a specific theory, chiral QCD[5], that predicts, among the other, an octet of massive bosons named *axigluons*. Vertices including axigluons have been summed up to LO QCD at the amplitude level; the limits that can be set on the mass of these new particles are reported in tab.4.

Table 4: Axigluon mass range (GeV) excluded at 95% CL. (CDF preliminary)

Strong interacting fermions	N=10	N=20
MT B2	$240 \leq M_A \leq 730$	$260 \leq M_A \leq 280$ & $420 \leq M_A \leq 580$
HMRSB	$220 \leq M_A \leq 640$	$240 \leq M_A \leq 330$ & $450 \leq M_A \leq 550$

5. References

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